ENVIRONMENTAL CONSIDERATIONS FOR NOISE BARRIERS

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1. INTRODUCTION

Rooftop noise barrier walls are often used as a low-cost, low-tech solution to control rooftop equipment noise from industrial and commercial facilities. However, these wall structures can cause structural loading issues. Thought should be given to environmental effects on barriers, since they can influence the structural design of roof systems, and the operation and performance of rooftop mechanical equipment.

Winds striking a barrier can create wind loads and torque on a rooftop barrier. These forces are transmitted into the building roof structure. The barrier itself also creates areas of localized shelter from the wind. As a result, snow particles slow down and drop to the nearest surface causing snow build up. The additional snow build-up can cause a significant weight increase on the roof and building structure. Snow loading is generally the dominant environmental effect resulting from the addition of the barrier. Since these additional loads are not typically taken into account during the initial building design, the weight can overload the roof and lead to roof structural failure. In fact, snow loading is one of the major causes of this type of structural collapse [1].

Snow accumulation can also inhibit or block airflow at intake and exhaust louvers [2]. Consequently, the performance of the HVAC system is reduced because of moisture intake and because the static pressure on the system increases. This can inevitably lead to a reduction in airflow and generate noise and vibration problems inside the building. Based on past experience, it is not uncommon for air handling units to become almost completely buried due to a heavy snowstorm.

Figure 1: Photo of Snow Accumulation on Roof

For these reasons, snow loading is an important factor that should be taken into account when considering a rooftop noise barrier.

2. CONTROL OF SNOW BUILD-UP

Incorporating a gap (approximately 0.25 m (10 inches)) below the barrier wall can help reduce the additional snow accumulation. The gap enables air to flow underneath the barrier, allowing snow scouring and preventing large drifts and accumulation of snow. This method has been employed in past RWDI projects such as the New Amundsen-Scott South Pole Station.

This effect can be illustrated using water flume simulations. Water flowing over a scale model simulates wind, and fine sand is used to replicate drifting snow. The simulation consisted of a 1:300 scale model of a 60 m long, square building, 6 m high, with a 0.3 m tall roof curb. For simplification, a single AHU was located at the center of the building, surrounded by a 3 m tall full perimeter barrier.

The model was used to investigate the drift patterns with and without a gap underneath the barrier. Two orientations were examined: "perpendicular," which is the longest barrier face perpendicular to the prevailing wind direction, and "45 degrees," which is the barrier at a 45° angle to the prevailing wind direction.

The water flume tests show that a barrier flush to the roof may result in large drifts between the barrier and AHU (up to 1 m high), as well as against the barrier (up to 1.5 m high), as illustrated in Figures 2 and 3.

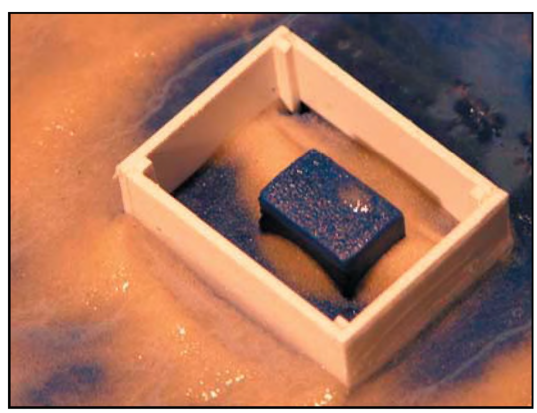

Figure 2: Barrier Flush to Roof, Perpendicular Orientation

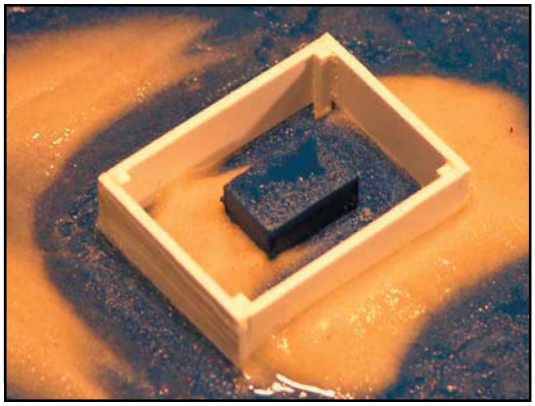

Figure 3: Barrier Flush to Roof, 45 Degree Orientation

An elevated barrier (0.25 m (10 in), full scale) results in little snow accumulation and increased snow scouring (see Figures 4 and 5). The gap causes increased wind flow under the barrier, with the resultant effect of reduced snow deposits in areas with accelerated wind flows. The elevated barrier causes the drift to form away from the barrier.

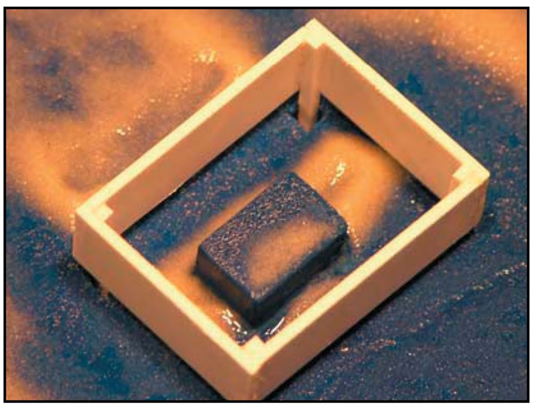

Figure 4: Elevated Barrier, Perpendicular Orientation

Figure 5: Elevated Barrier, 45 Degree Orientation

3. ACOUSTICAL EFFECTS

Although incorporating a gap below the barrier is beneficial from a snow loading perspective, it can also provide a major path for noise to escape, thereby lessening its ability to reduce sound. To investigate the behavior of sound around the barrier configurations, an idealized 3D computer model was created. Receptors were located 15, 55, and 100 meters away from the facility, and at various heights of 1.5 to 12 meters. Cadna/A version 3.4.109, a computerized version of ISO 9613, was used to calculate the data.

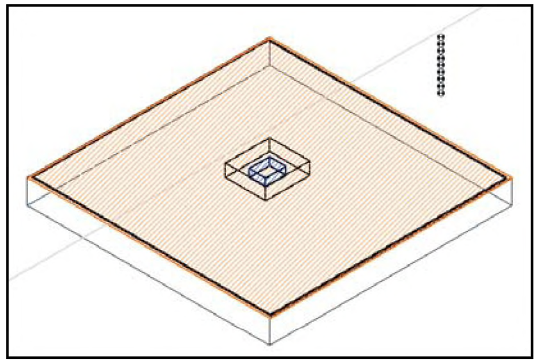

Figure 6: 3-D Cadna Computer Model

Three scenarios were examined:

- Building without rooftop barrier
- Building with 3.0 m high rooftop barrier, with no gap
- Building with 3.0 m high rooftop barrier, with a 0.25 m (10 inch) gap

The assumptions used for the computer model:

- The surrounding ground is acoustically absorptive (G = 0.8)
- The rooftop is generally acoustically reflective (absorption $\alpha = 0.1$)
- Barrier is sound absorptive on the equipment side (1” fiberglass behind perforated metal)
- The casing of the AHU is reflective sheet steel
- Order of reflection of 2

The results of the analysis are presented in Table 1.

Table 1: Summary of Results

Receptor Height (m)	Resultant Sound Level (dBA)								
	No Barrier			Barrier Flush to Roof			Barrier with 10 inch Gap		
	15m	55m	100m	15m	55m	100m	15m	55m	100m
1.5	42	45	42	38	38	36	40	39	36
3	45	46	43	39	39	35	42	39	35
4.5	49	47	43	43	39	35	43	39	36
6	53	49	45	42	38	35	43	39	35
7.5	58	51	46	46	39	35	47	40	36
9	60	52	47	53	42	36	56	43	37
10.5	60	53	47	56	47	36	58	48	37
12	60	53	48	57	48	42	58	49	42

The plots presented in Figures 7, 8, and 9 provide a graphical illustration of the sound level results in Table 1. The results are for the receptors outlined above.

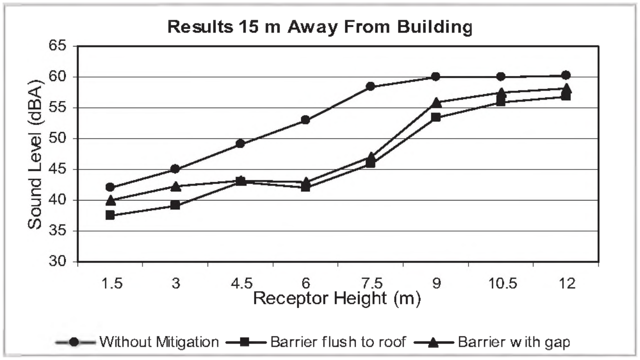

Figure 7: Results 15 Meters Away from Building (fixed font size)

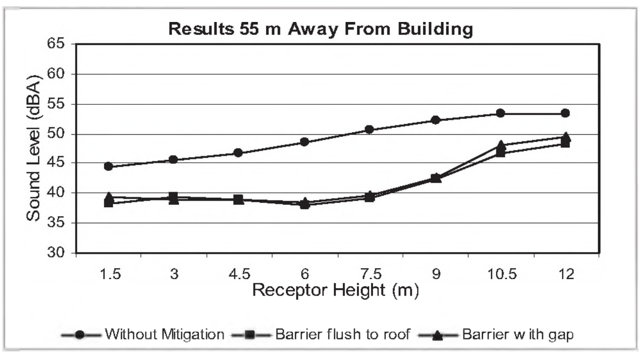

Figure 8: Results 55 Meters Away from Building

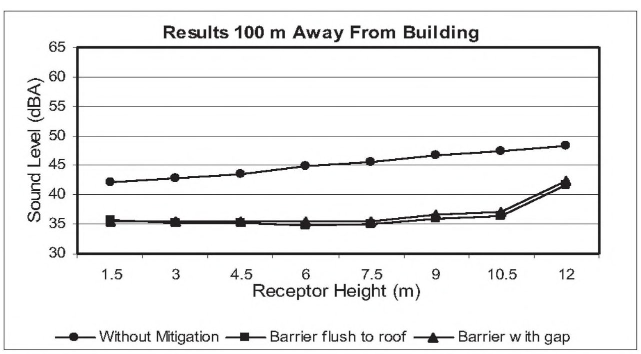

Figure 9: Results 100 Meters Away from Building

As shown in Figure 7, close to the barrier, the gap reduces the barrier's performance by up to 3 dB. However, as shown in Figures 8 and 9, as the source-receiver distance increases, the effect of the gap on barrier performance decreases. At 55 m and 100 m from the facility, the gap results only in minor sound level increases of up to 1 dB, a level considered to be imperceptible to humans.

As an additional comparison, a cross section illustrating noise contours for the non-elevated and elevated barriers are shown below in Figures 10 and 11.

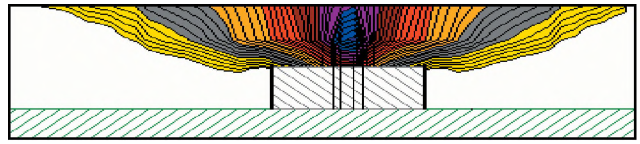

Figure 10: Section of Noise Contours for Non-Elevated Barrier (adjusted picture dimensions)

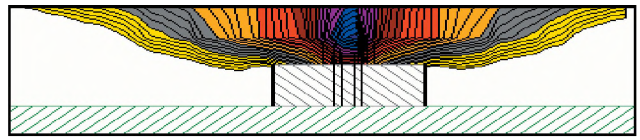

Figure 11: Section of Noise Contours for Elevated Barrier (adjusted picture dimensions

The noise contours with the elevated barrier (Figure 11) extend slightly wider than the non-elevated barrier (Figure 10) above the building. However, the overall noise contours are still similar in shape, further illustrating that the gap has a minor affect on the barrier's performance.

4. CONCLUSION

Environmental snow loading issues associated with rooftop noise barriers can be reduced with proper mitigative strategies. Placing a small gap (0.25 m (10 in)) at the base of the barrier can reduce snow accumulation with minimal acoustical effects at distant receptors. Where receptors are to be located closer than 50 m to the source, the acoustical effects of the gap should be considered, using a proper ray-tracing model.

5. REFERENCES

[1] RWDI Technote Issue 1, "Assessing Snow Loads", Colin J. Williams, Ph.D., P.Eng.

[2] RWDI Technote Issue 5, "Working with Nature", Bill Waechter, C.E.T.